An Introduction to Amateur Satellites

2007 AMSAT Symposium

Pittsburgh, PA

Gould Smith, WA4SXM

AMSAT VP User Services

AO-51 Command Station

Some Satellites act like single channel repeaters

- Retransmit what they "hear"
- Have Optimized Receivers, Transmitters, Antennas
- Great Location!
- Allows Communications Over Great Distances

How satellites differ from Repeaters

- Have a Moving Footprint!
  - –Location Changes / Availability Varies
  - –Frequency Changes due to Doppler Shift
- Full Duplex
  - –Simultaneous Uplink and Downlink on Different Bands
  - – Multi-mode (CW/SSB/Digital/SSTV/PSK31)
- "World Wide" Coverage

Some satellites are "Transponders"

- Receives a SEGMENT of One Band
- Retransmits EVERYTHING It Hears
- Inverting Transponders
  - Lowest Incoming Frequency is Retransmitted Over the Highest Outgoing Frequency
  - Inverts Signal (LSB to USB)
- FM Sat Retransmit one station (up 2m/dwn 70cm)

Example for VO-52:

Mode B Uplink: 435.225 - 435.275 MHz LSB/CW

Mode B Downlink: 145.875 - 145.925 MHz USB/CW

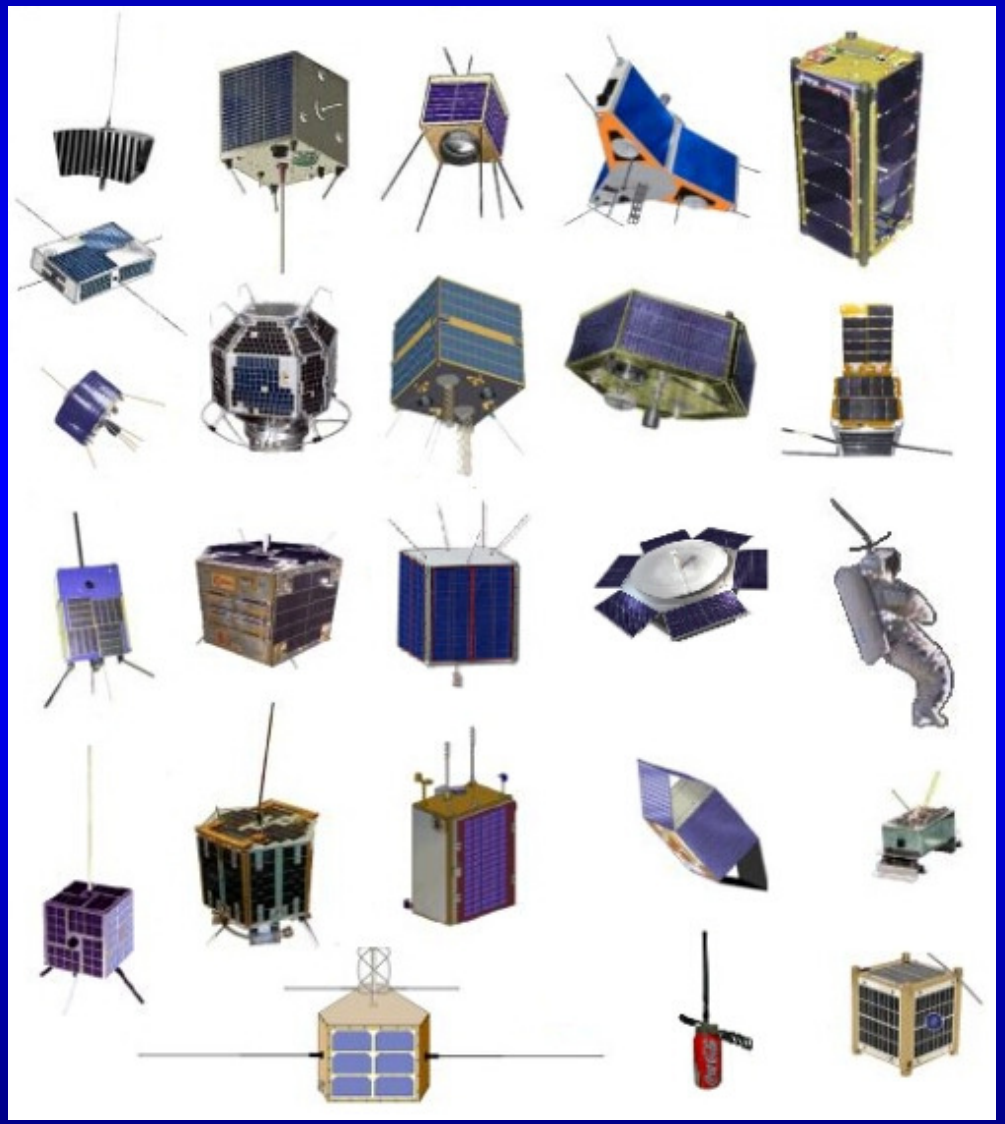
VO=Carrier 145.940/PA=CW Msg at 145.860 Mhz.

Available Satellite Bands

- Bands Exist from 15 Meters to 24 GHz
  - Set by International Convention
  - Not all Amateur Bands allocated for Satellites (e.g. 6 Meters, 220 MHz)
- 70 cm/2M Most Often Used
- Various 'Modes'
- There is a shift towards Higher Frequencies
- "Use It or Lose It"

Satellite Characteristics Differ

- Digital/Analog
- Orbital Parameters
- Frequencies Utilized
- "Payload"

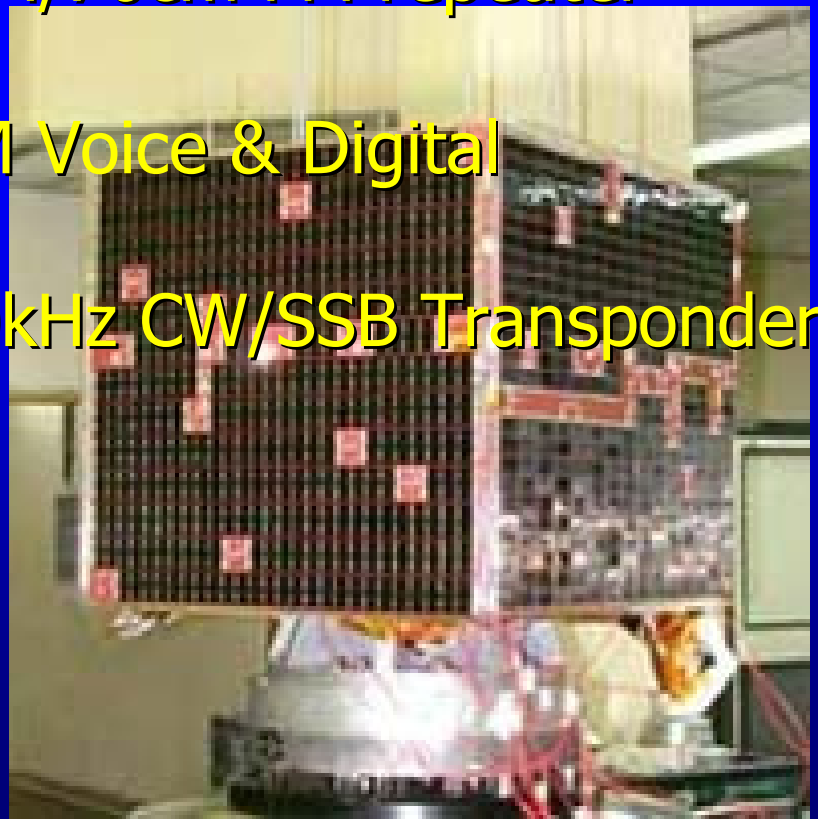


A Wide Variety of Satellites Exist

- 8 Satellites Currently in Operation + ARISS
  (6 fully functional, 3 semi-operational)
- Digital Store and Forward
- FM Repeater 2 Meter/435 MHz
  1.2 GHz/2.4 GHz
- SSB/CW 2 Meter/435 MHz
  2 Meter/10 Meter

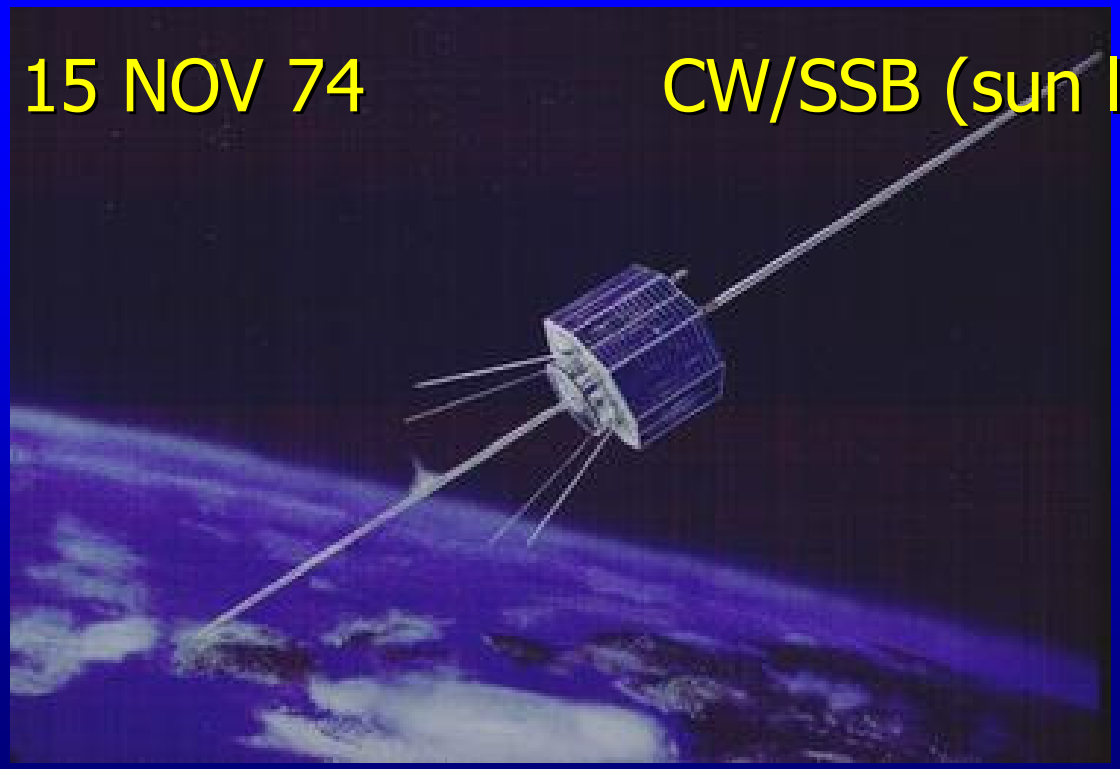
OSCAR Satellites Operational

Satellite	Launch	Comments
AO-27	26-Sep-93	FM Voice
GO-32	10 JUL 98	Digital Store & Forward BBS
SO-50	20 DEC 02	2M/70cm FM repeater
AO-51	29-June-2004	FM Voice & Digital
VO-52	5-May-2005	60kHz CW/SSB Transponder



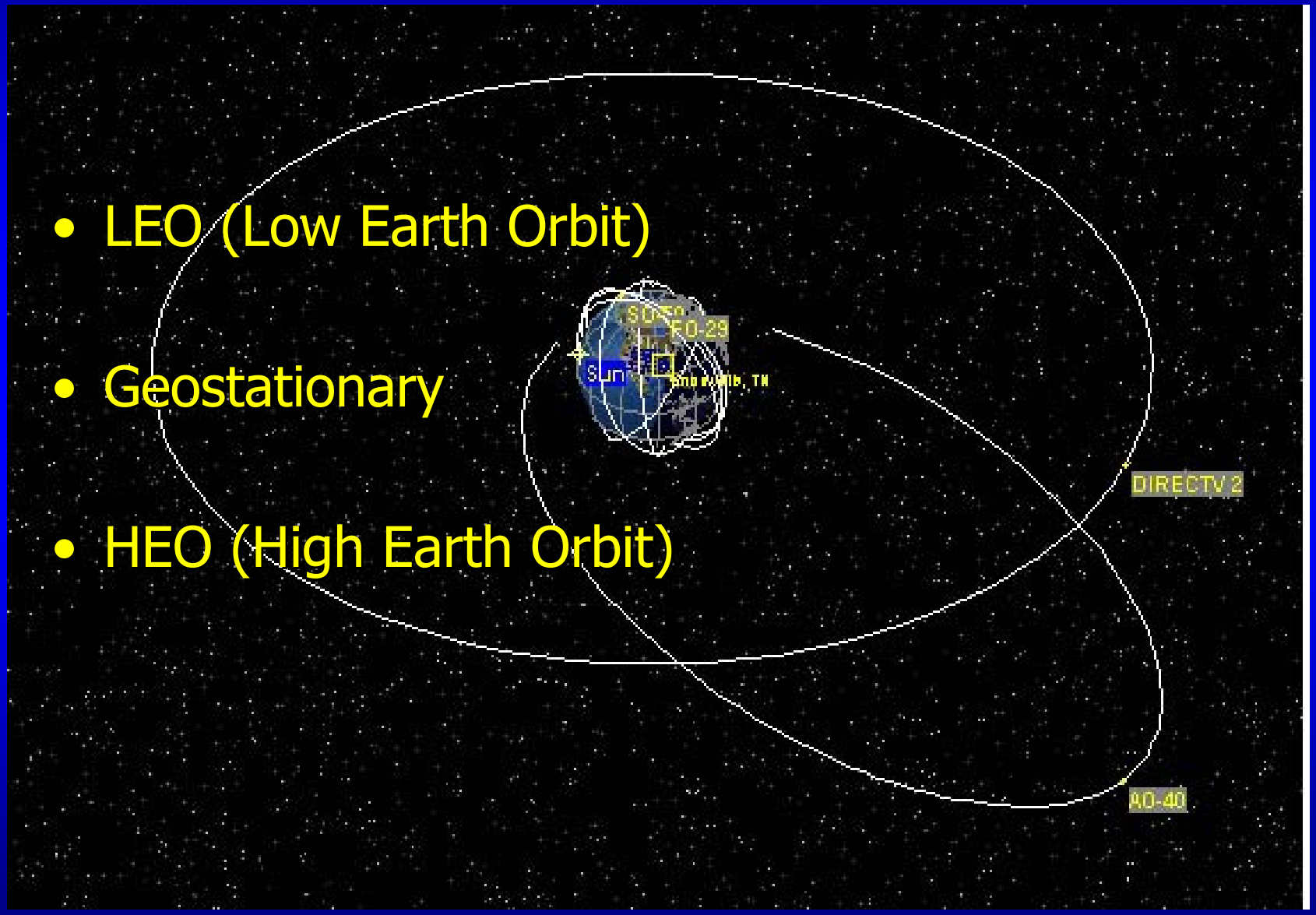
OSCAR Satellites Semi-Operational

Satellite	Launch	Comments
FO-29	17 AUG 96	100 kHz SSB Transponder
LO-19	22-Jan-90	Telemetry only
AO-7	15 NOV 74	CW/SSB (sun light ops only)

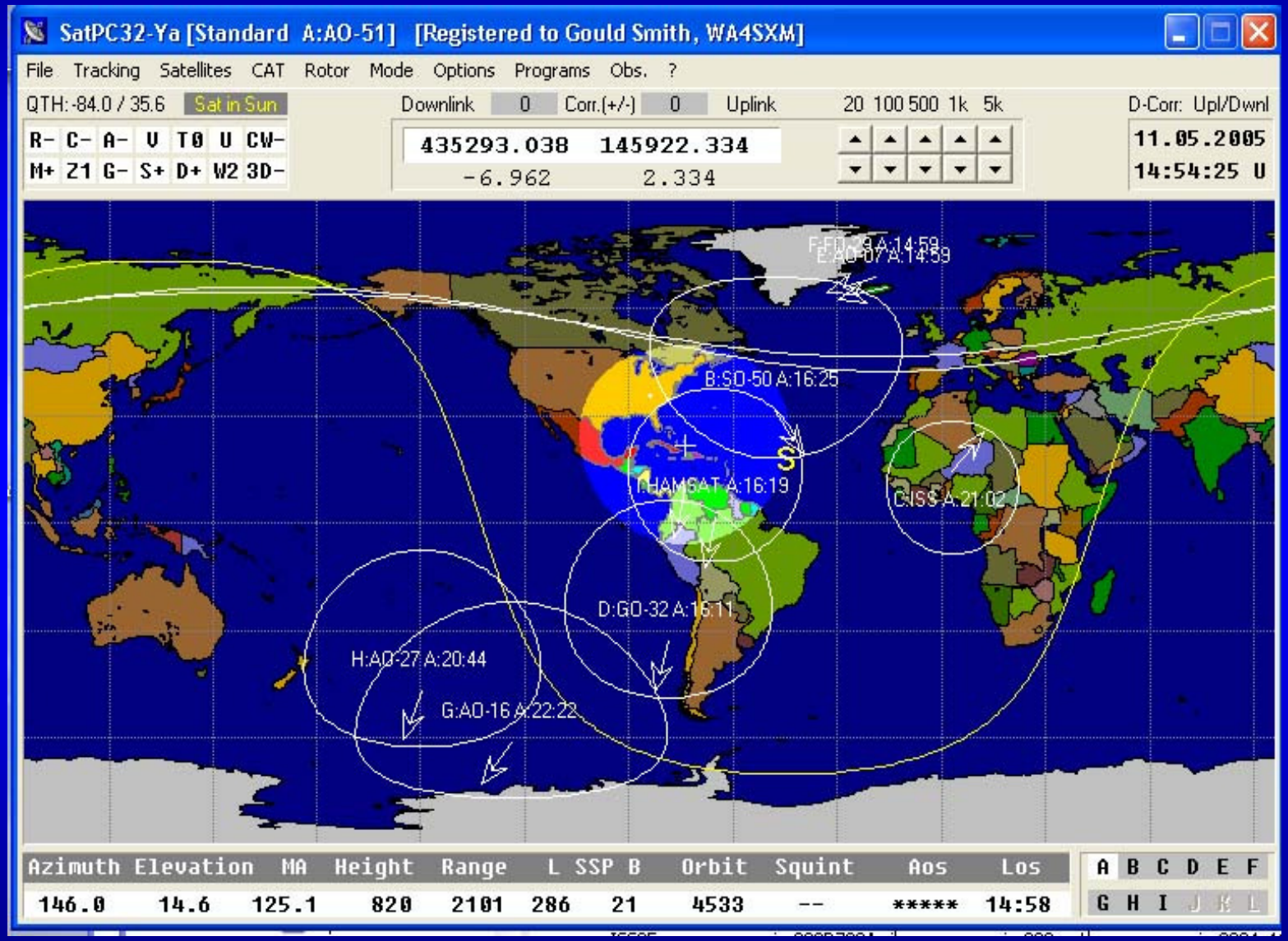


Satellite Orbits

- LEO (Low Earth Orbit)
- Geostationary
- HEO (High Earth Orbit)

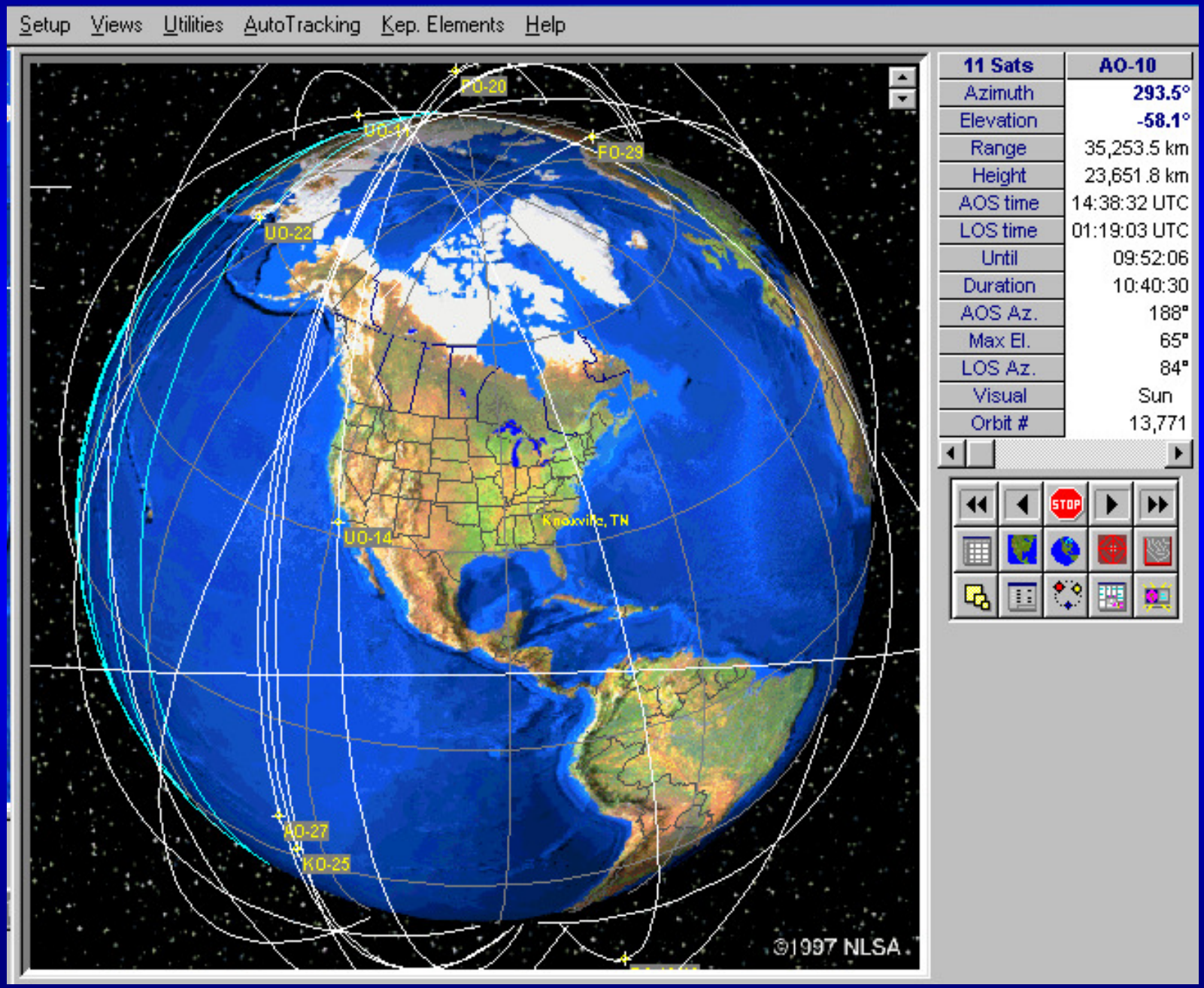


SatPC32 software

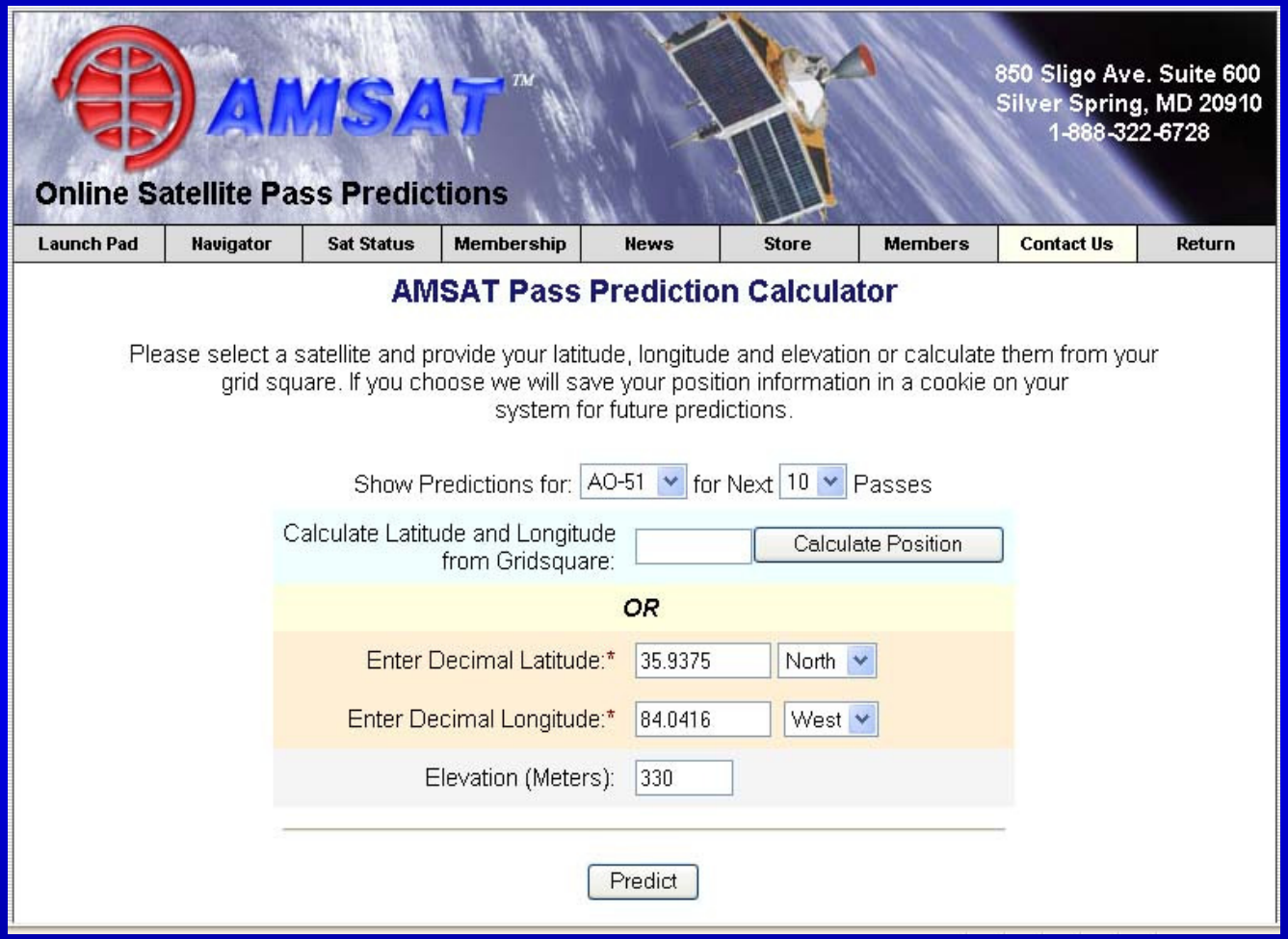

SatPC32-Ya [Standard A:AO-51] [Registered to Gould Smith, WA4SXM]
File Tracking Satellites CAT Rotor Mode Options Programs Obs. ?
QTH:-84.0 / 35.6 Sat in Sun
Downlink 0 Corr.(+/-) 0 Uplink
20 100 500 1k 5k
D-Corr: Upl/Dwnl
435293.038 145922.334
-6.962 2.334
11.05.2005
14:54:25 U
B:SO-50 A:16:25
I:HAMSAT A:16:19
D:GO-32 A:16:11
H:AO-27 A:20:44
G:AO-16 A:22:22
Azimuth Elevation MA Height Range L SSP B Orbit Squint Aos Los
146.0 14.6 125.1 820 2101 286 21 4533 -- ***** 14:58

Will also do antenna and radio control

Nova


Setup Views Utilities AutoTracking Kep. Elements Help
FO-20
UO-11
FO-29
UO-22
UO-14
Knoxville, TN
AO-27
KO-25
©1997 NLSA.
11 Sats
AO-10
Azimuth 293.5°
Elevation -58.1°
Range 35,253.5 km
Height 23,651.8 km
AOS time 14:38:32 UTC
LOS time 01:19:03 UTC
Until 09:52:06
Duration 10:40:30
AOS Az. 188°
Max El. 65°
LOS Az. 84°
Visual Sun
Orbit # 13,771
STOP

AMSAT also provides online predictions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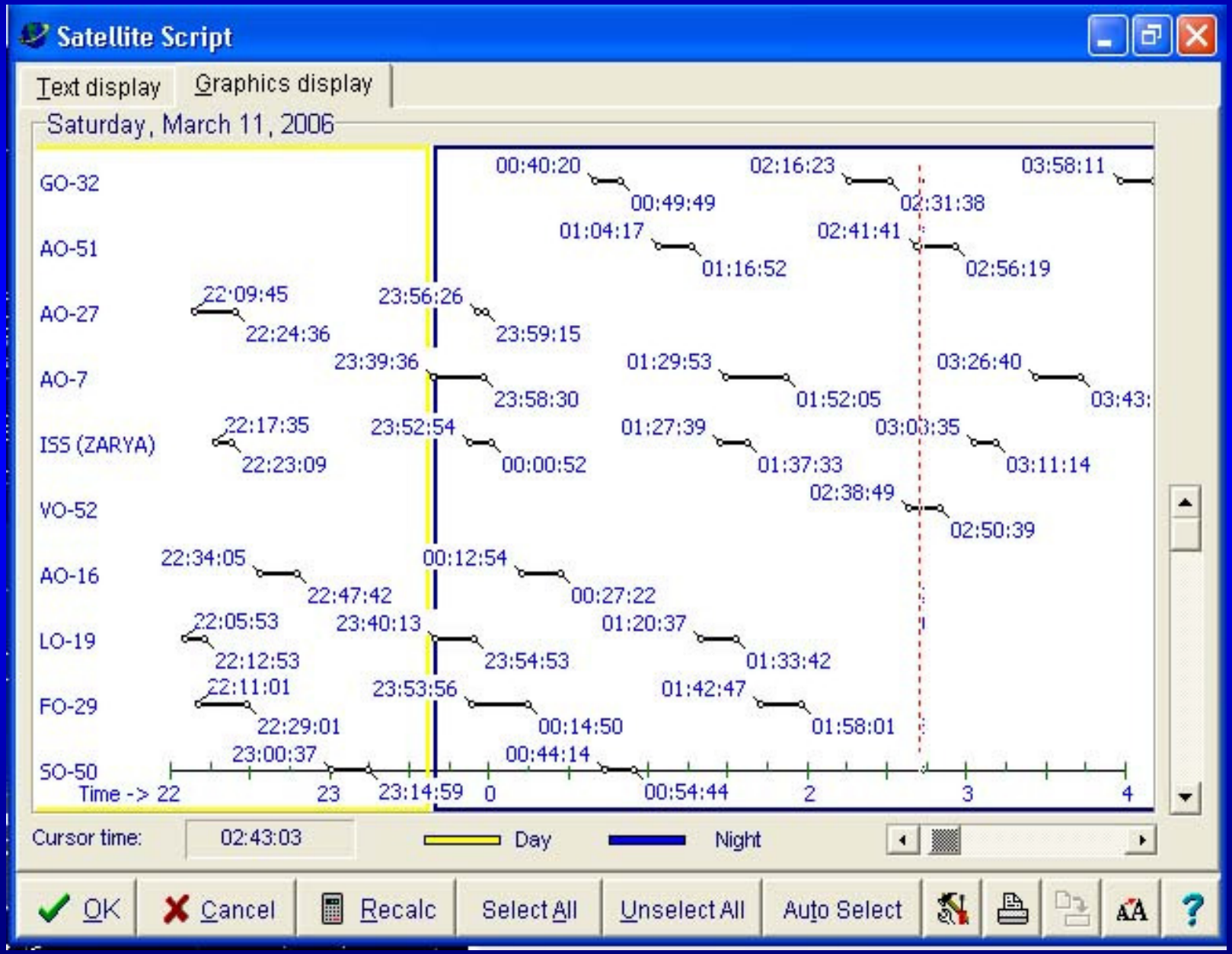
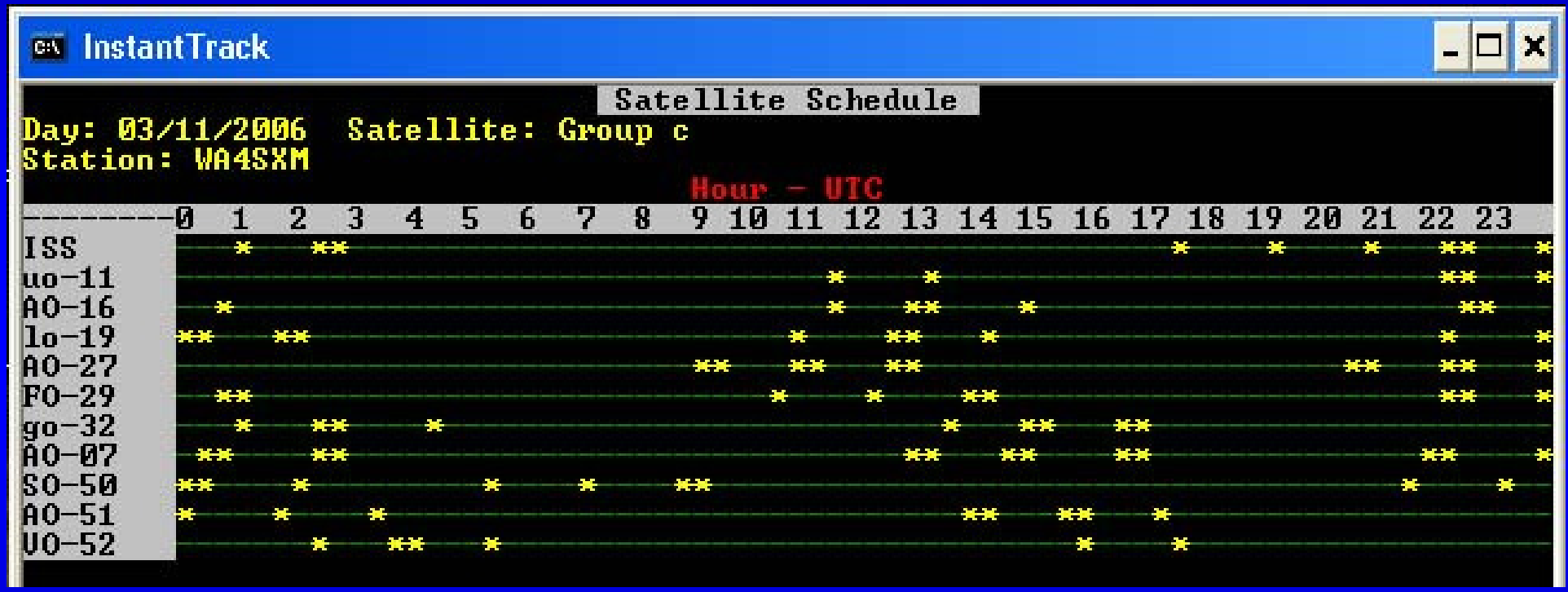
AMSAT Pass Prediction Calculator
Please select a satellite and provide your latitude, longitude and elevation or calculate them from your grid square. If you choose we will save your position information in a cookie on your system for future predictions.
Show Predictions for: AO-51 for Next 10 Passes
Calculate Latitude and Longitude from Gridsquare:
Calculate Position
OR
Enter Decimal Latitude:* 35.9375 North
Enter Decimal Longitude:* 84.0416 West
Elevation (Meters): 330
Predict

6pm – midnight EST operations



When are the satellites available?



- Answer: nearly all the time.

Getting Started

EASY 'sats' FM Birds (Low Earth Orbit)

- FM Satellites: AO-51, SO-50, AO-27
- Human Spacecraft (ARISS)

Minimum Ground Station:

- Dual Band Handheld (2m/70cm) full duplex mode
- Dual Band Arrow or yagis or high gain whip antenna

- **SSB & CW sats**
  - SSB/CW VO-52 HAMSAT (India)
  - SSB/CW AO-7
  - SSB/CW FO-29 Satellites (Japan)

- Longer passes, multiple QSOs because 50 kHz bandwidth

AO-51 (Echo)
AMSAT-NA's newest satellite

- Improved Microsat (9.5x9.5in)
- Built by SpaceQuest,Ltd. in Fairfax, VA
- FM repeater 2M/23cm (67 PL) uplink, 70cm/13cm downlink
- 9600 bps AX.25 FSK Digital
- Launched June 29, 2004 into Sun Synchronous, Polar Orbit approx. 850 km high
- Monthly Experimental modes

Fixed Station Requirements

- Small yagis, fixed elevation, TV rotor
- 70 cm preamp at the antenna
- Satellite radio or two radios
- Low power
- Optional computer control of rotor and Doppler

Minimal equipment needed to operate the FM sats

- Dual band handheld
- Arrow antenna

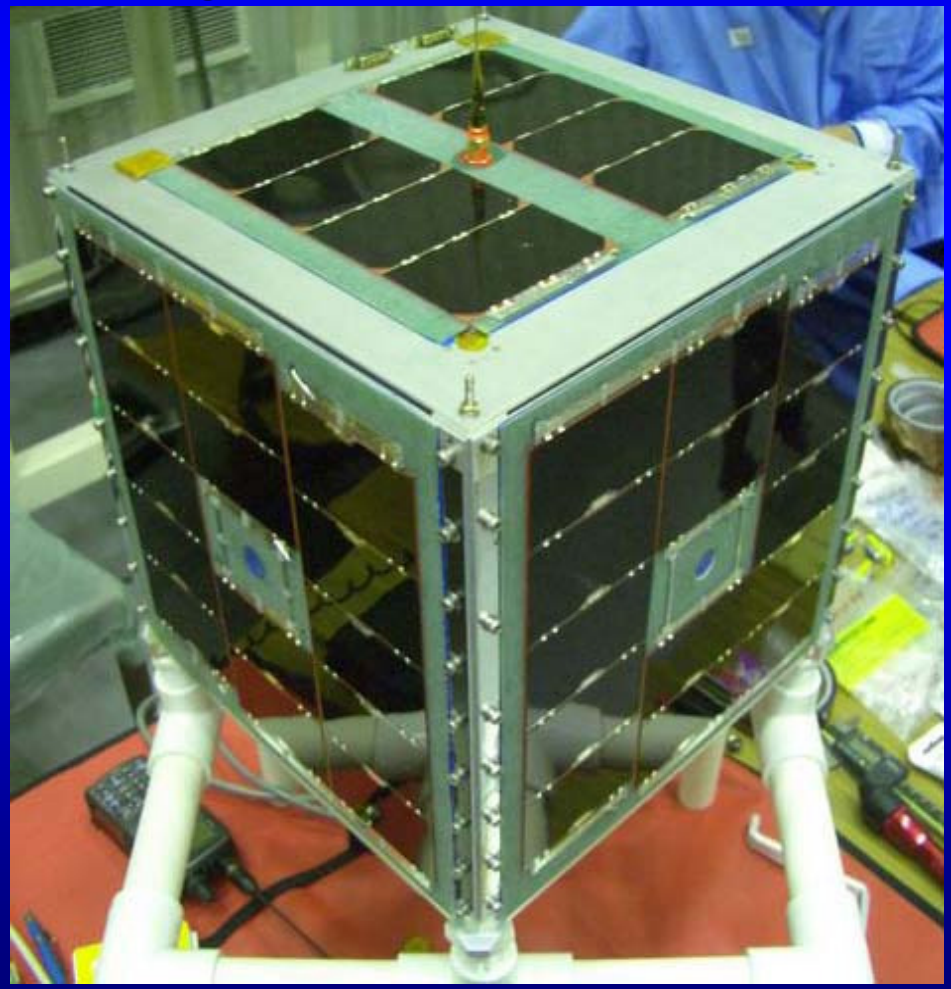
AO-51 Standard Operation

- **Analog - Voice**
  - Downlink 435.300 MHz FM
  - Uplink 145.920 MHz FM
  - TX power is 0.5 - 1 Watt, but may be as high as 1.2 Watts.

- **Digital – 9600 bps,**
  AX.25, PACSAT Protocol
  - Downlink 435.150 MHz FM
  - Uplink 145.860 MHz FM *

  Telemetry in the digital stream

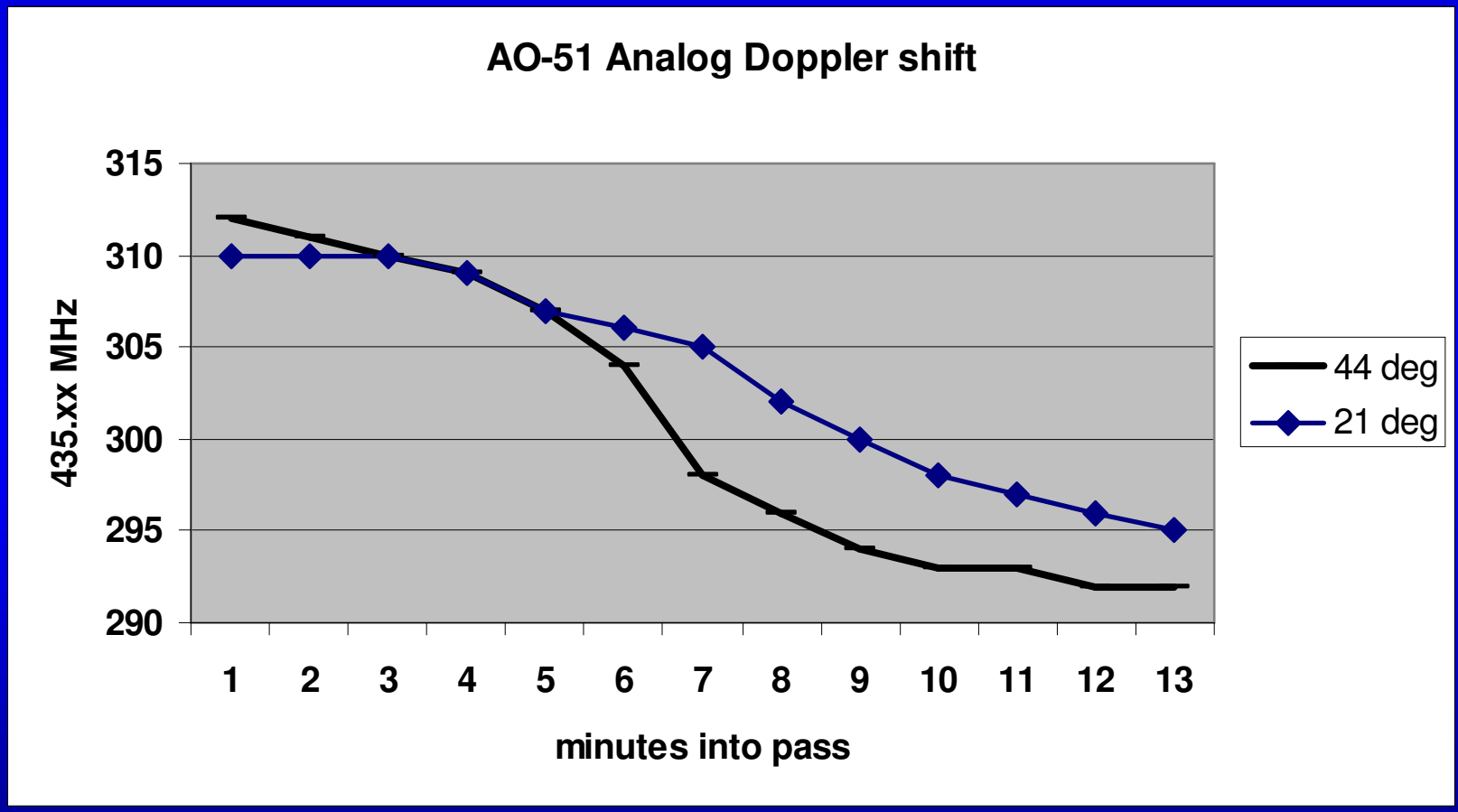
*currently not available



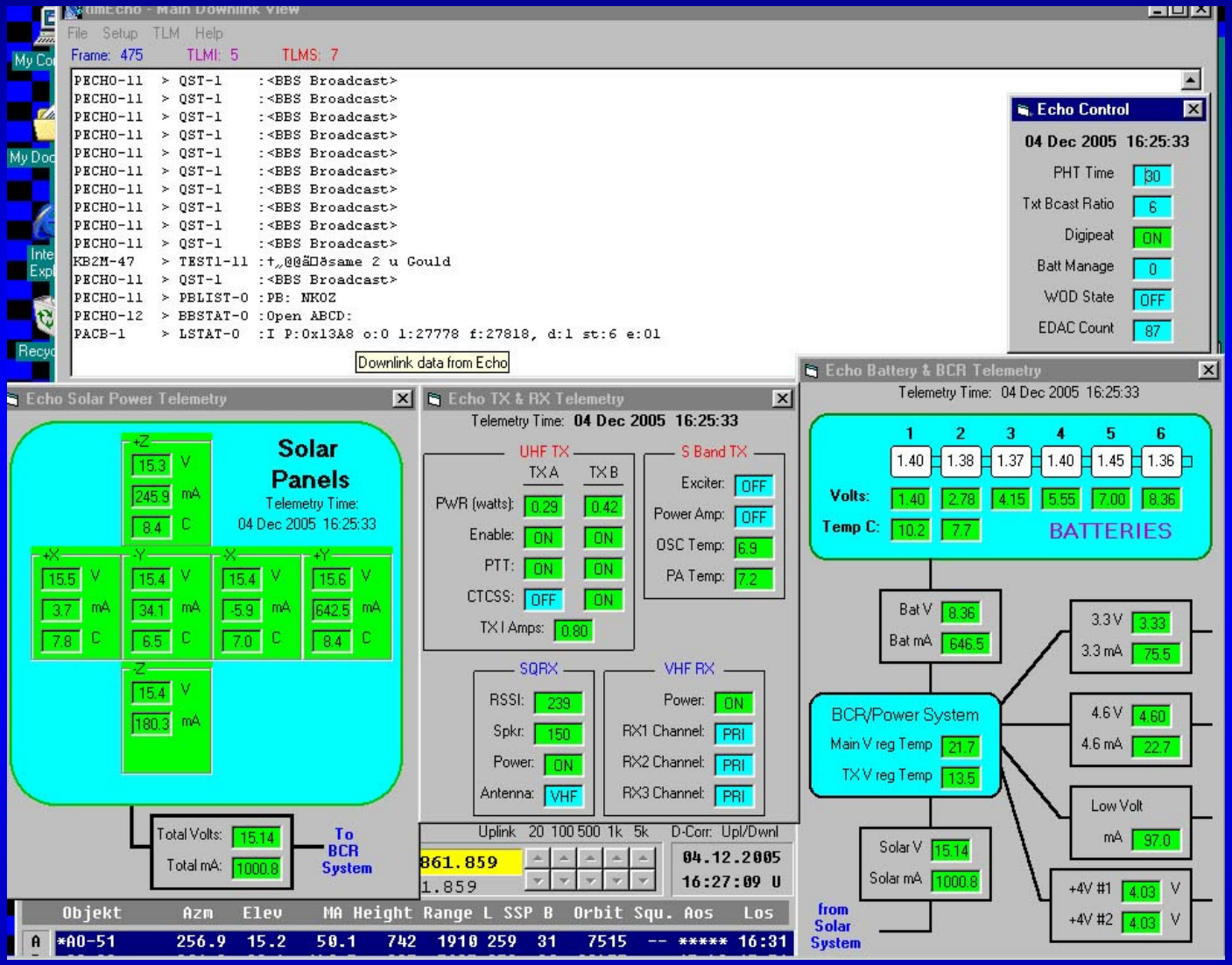
AO-51 Analog Operating Techniques During the Pass

- Adjust for Doppler (20 kHz, -10 kHz to +10 kHz)
- Listen to who is talking - note the call-sign
- Make a short call to this specific station
- Give your name, callsign, and grid square
- Have a means to record contacts
- Have patience-LEO satellites are busy, so it may take a few passes until you make a contact

Doppler Shift



AO-51 Telemetry



TlmEcho v1.1.1 available: http://www.amsat.org/amsat-new/echo/
MacEchoTelem: http://dogparksoftware.com/MacEchoTelem.html.

AO-51 Experimenter's Day Options

- Multi-band, multi-mode SQRX receiver (10 MHz –1.3 GHz), used for **L band uplink** (23cm) (voice and 38k4 digital)
- **S Band** (13cm) FM Downlink, L Band or 70 cm uplink
- Cross band, cross mode repeater (2M SSB up, 70cm FM down)
- **APRS,** can digipeat up to a 20 character status message to APRS network or QSO with other online users
- **PSK-31 -** Uplink of 10M SSB with UHF FM downlink
- **Check ANS** bulletins and AMSAT web site ECHO area for info on upcoming Experimenter's Wednesday plans

AO-51 Operational Mode Today

- **V/U FM Repeater**
  - Uplink 145.920 MHz
  - Downlink 435.300 MHz (+-20 kHz Doppler)

- **V/U FM 9k6 digital downlink**
  - Uplink none
  - Downlink 435.150 MHz (+- 20 kHz Doppler)

* Uplink band /downlink band

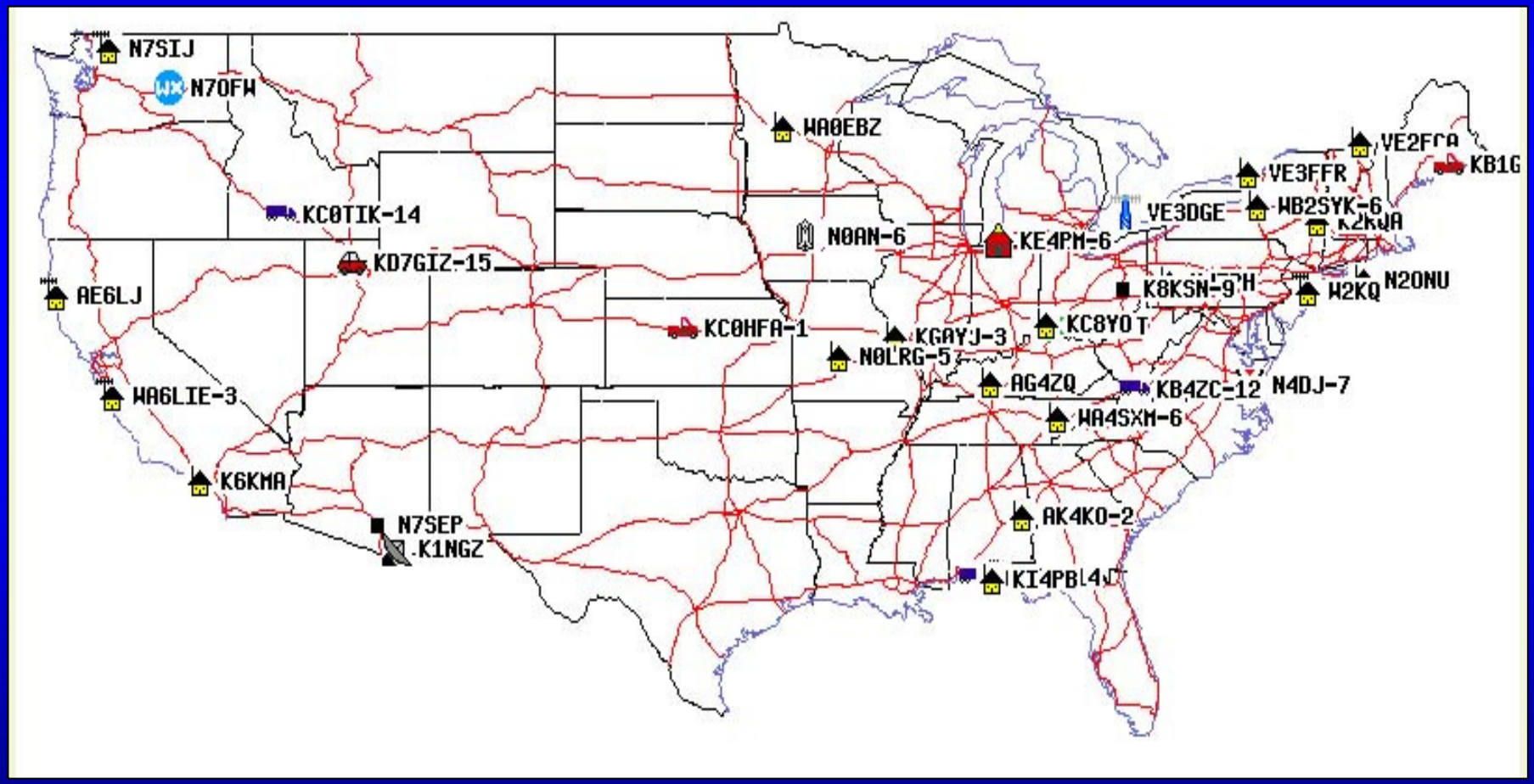
SO-50 (SaudiSat 1-C)

- U/V FM repeater
- Uplink needs 67 Hz tone
- Not a polar orbit, so pass times change day to day
- 250 mW transmitter

Amateur Radio on the ISS (ARISS)

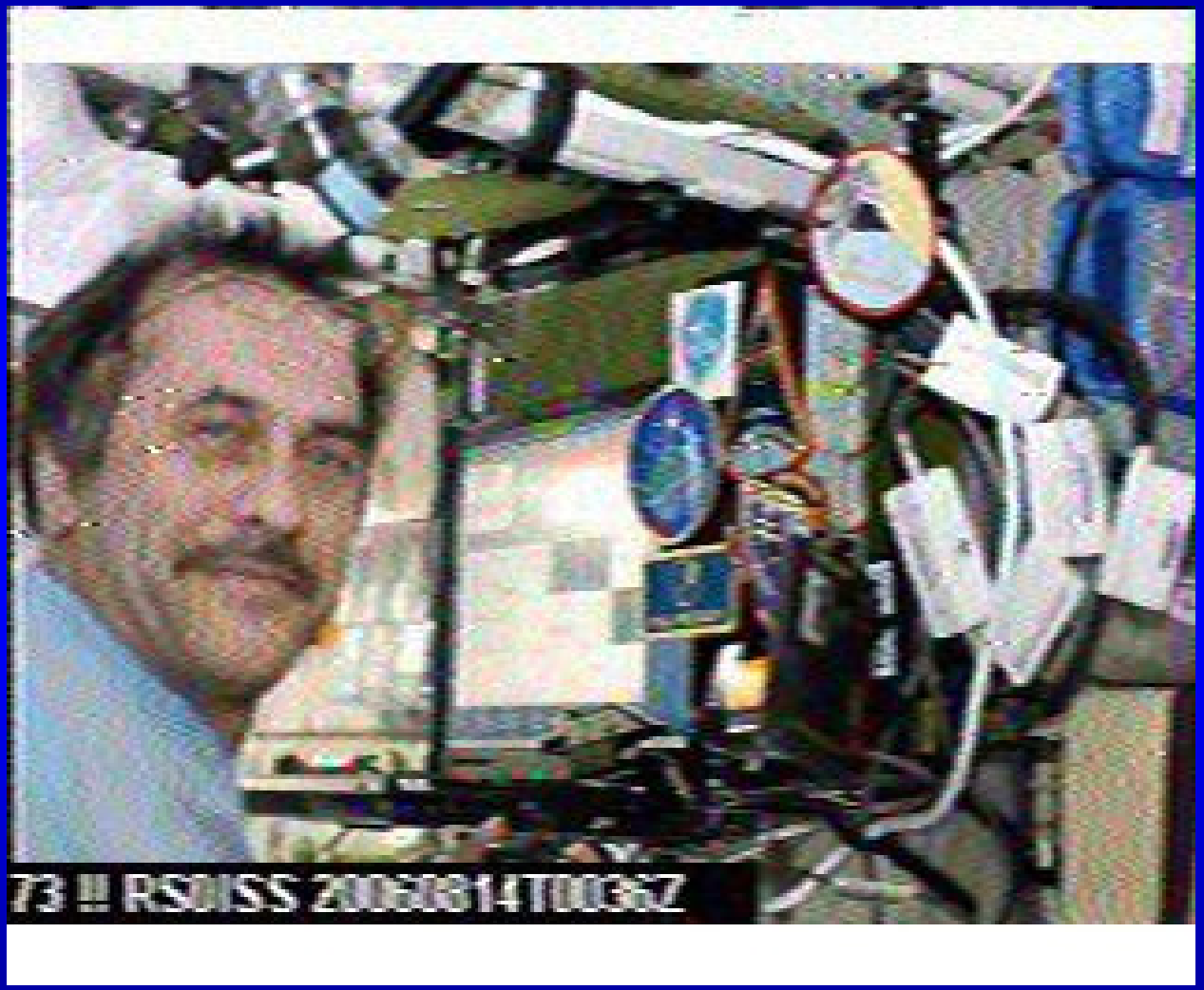
- Voice operations
  2M and 70cm
- Digipeater
- Cross-band repeater
- School contacts
- Future SSTV

ISS digipeat map at http://www.ariss.net/index.cgi



SuitSat-1 becomes AO-54

SSTV from the ISS



2M FM downlink, ROBOT 36 format

Bill McArthur, KC5ACR

- Expedition 12
- 37 school contacts
- >1755 general contacts
- 130 DXCC entities

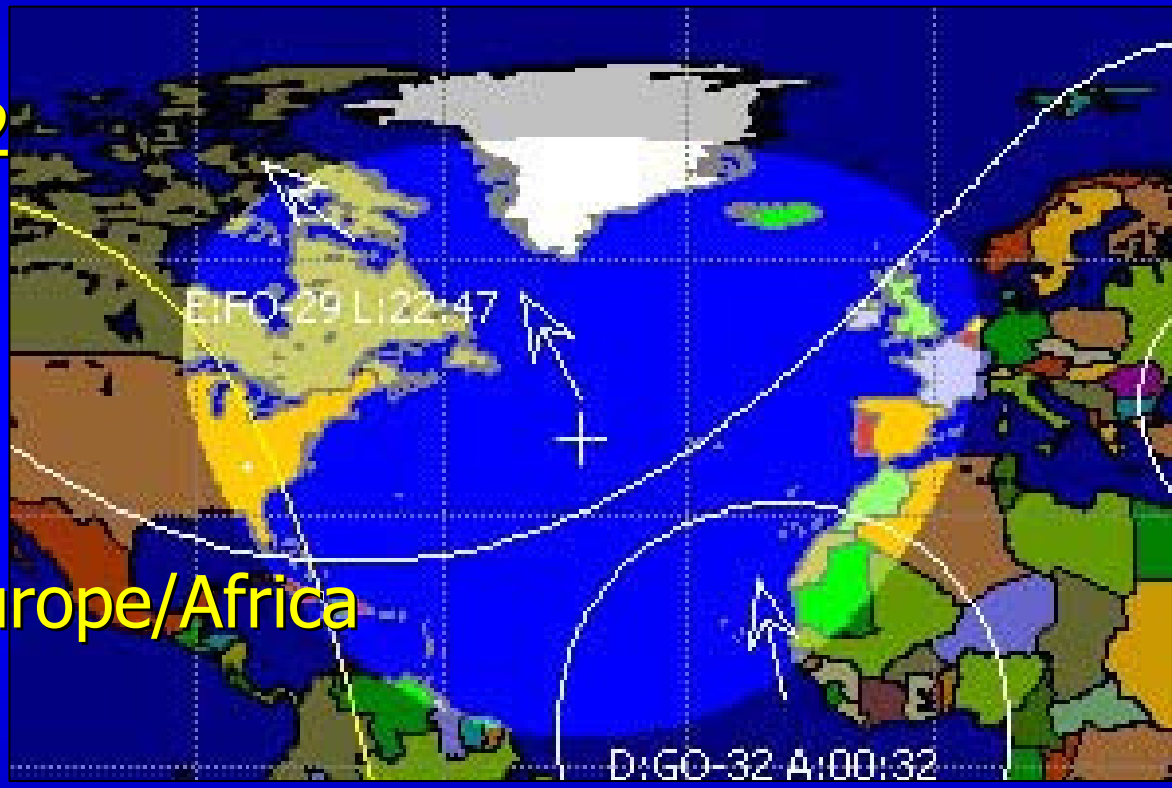
Bill using the on-board D-700A

VO-52

- HamSat launched in 2005
- India's first amateur satellite
- 60 kHz wide transponder
- Uplink 435.250 MHz
- Downlink 145.9 MHz
- Voice and CW

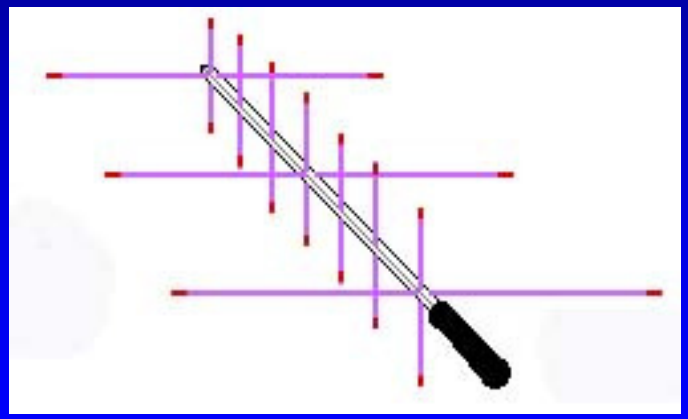
AO-7

- Launched in 1974
- Came back to life in 2002
- 100 kHz bandwidth
- Great coverage area,
- eastern US to western Europe/Africa
- 1450 km altitude



- Randomly comes up in Mode A or Mode B
  - 2M SSB uplink, 10M SSB downlink (Mode A) or
  - 70cm SSB uplink, 2M SSB downlink (Mode B)

AO-7 Receive



2M→10M
downconverter

HF receiver

AO-7 Operation

Mode U/V **Beacon 145.975 MHz**

Uplink	Downlink	Downconverter
432.125	145.975	(28.975)
432.130	145.970	(28.970)
432.135	145.965	(28.965)
432.145	145.955	(28.955)←
432.155	145.945	(28.945)←
432.165	145.935	(28.935)
432.175	145.925	(28.925)

AO-7 Alternate Mode

Mode U/A **Beacon 29.502 MHz**

Uplink	Downlink	
145.850	29.400	
145.860	29.410	
145.880	29.430	
145.890	29.440	
145.900	29.450	Center of pass band
145.910	29.460	
145.920	29.470	
145.930	29.480	
145.940	29.490	
145.950	29.500	

CubeSats

- 10cm cube
- Mass up to 1kg
- University or group sponsors
- Multiple CubeSats fit in a spring launcher
- Info at Cubesat.org
- Stanford and Cal Poly designs
- Workshops every other year

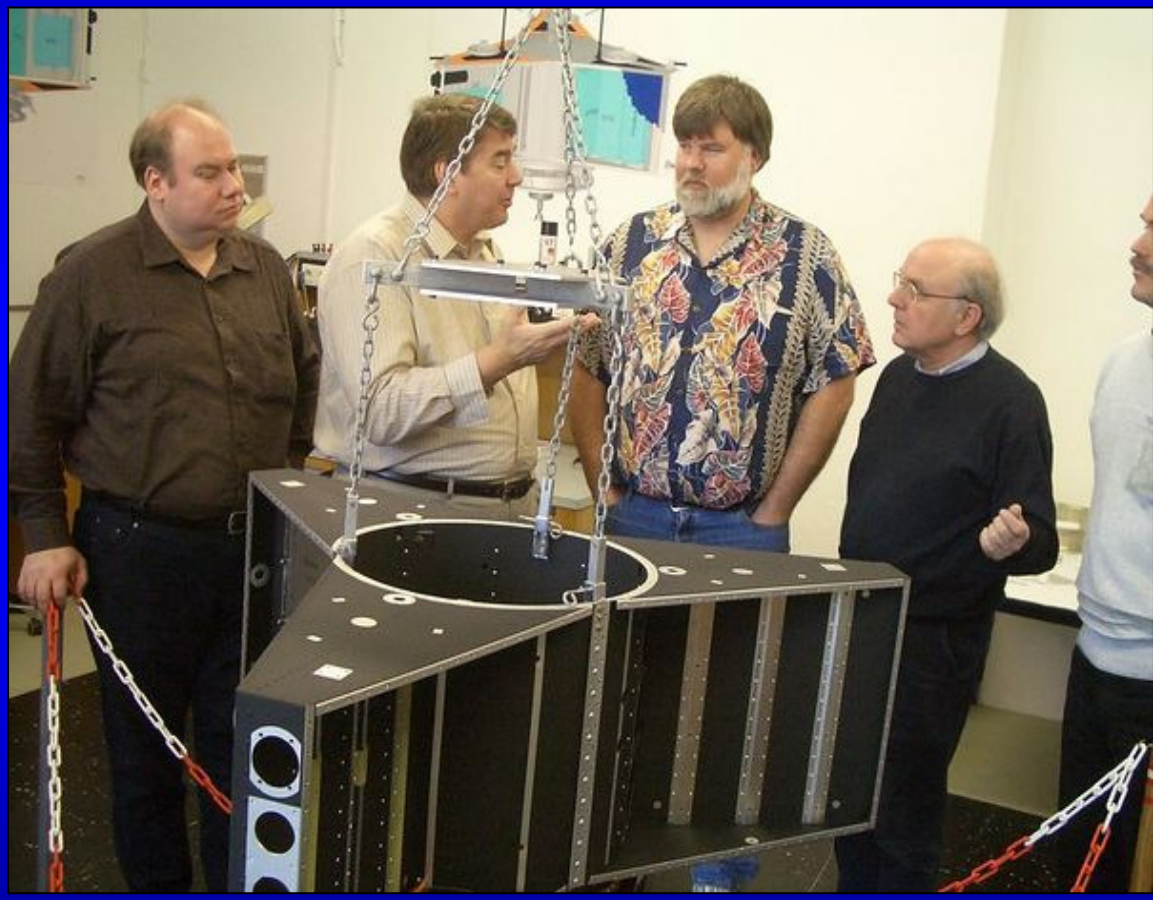
The new AMSAT Vision:

Our Vision is to deploy high earth orbit satellite systems that offer daily coverage by 2009 and continuous coverage by 2012

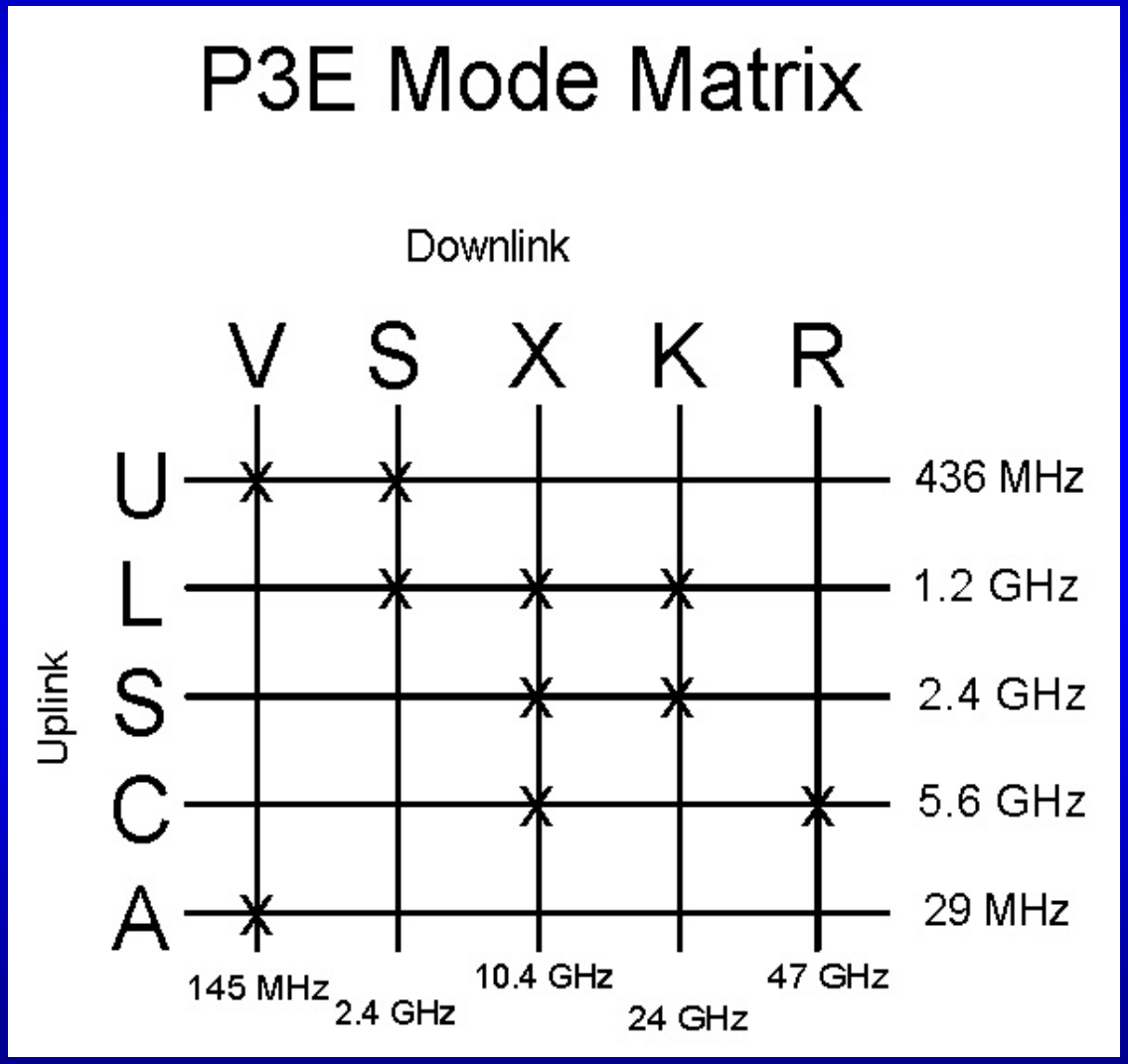
AMSAT will continue active participation in human space missions and support a stream of LEO satellites developed in cooperation with the educational community and other amateur satellite groups

AMSAT-DL P3E "Express"

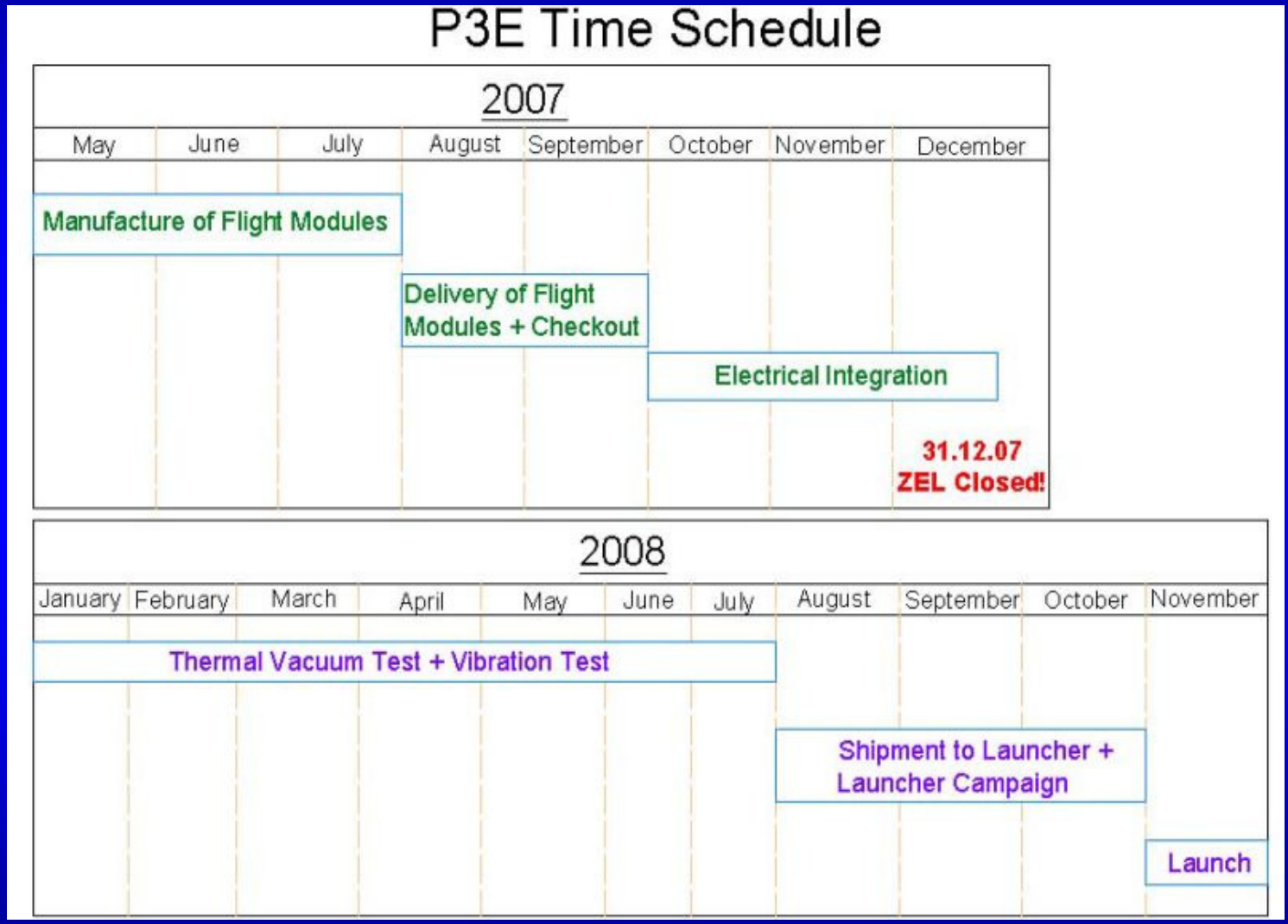
- Designed & Built by AMSAT/DL with US help
- HEO, 36000km x 2500km Highly elliptical
- 100kHz. Transponders V, U, L, S, C, K, X bands
- Analog & Digital modes
- Projected launch is 2007



P3E Transponders



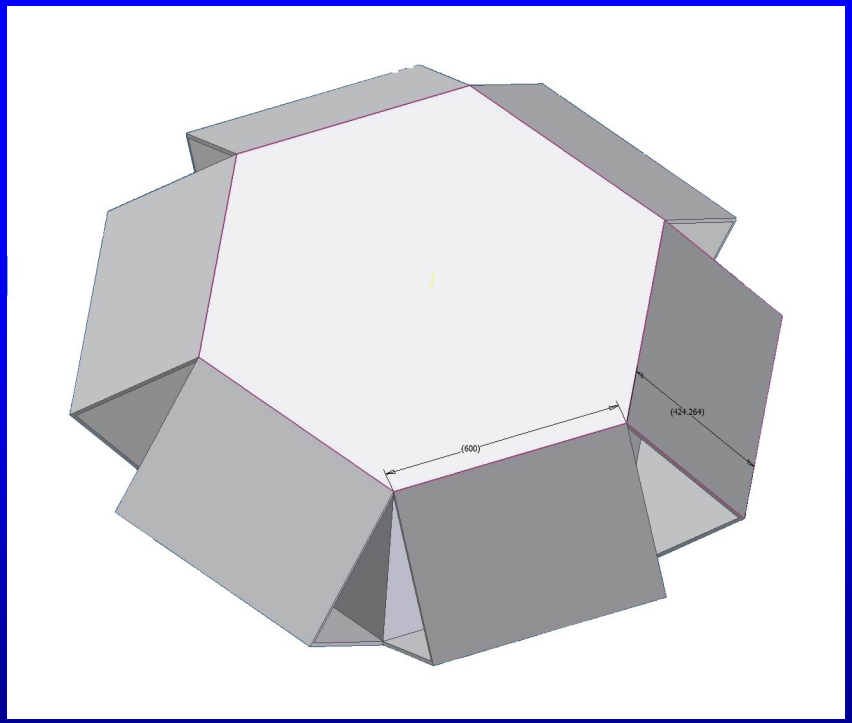
P3E Schedule

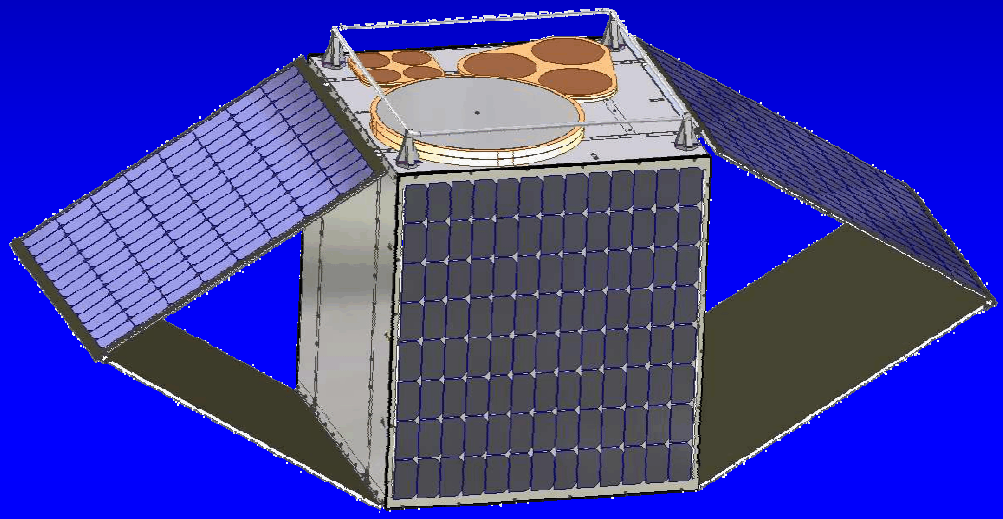


AMSAT-NA's EAGLE satellite

AMSAT

Eagle!

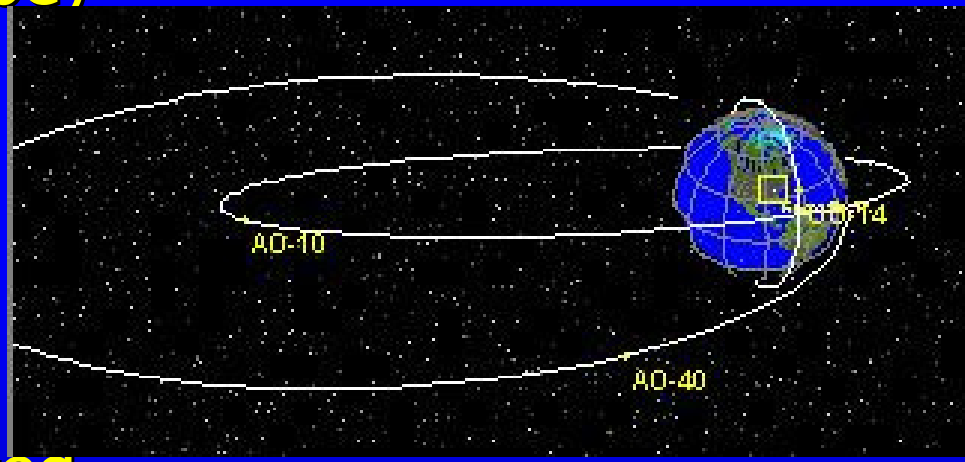




Eagle: AMSAT's Next Project

The following has been announced:

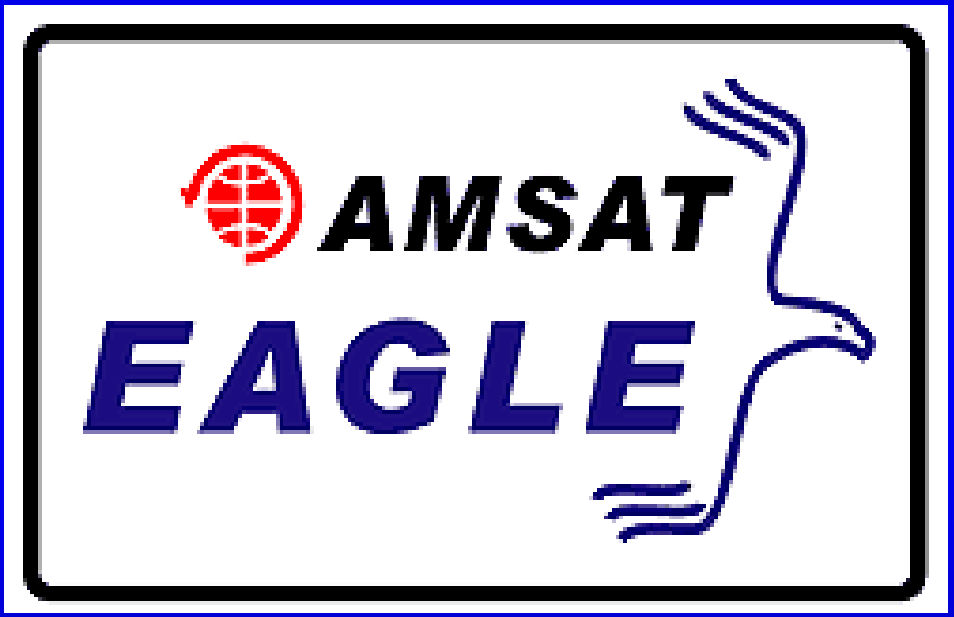
- **High Earth Orbit** (e.g. at apogee, it gives service to half the globe)
- **13 hour access windows**
- **SDX** (Software Defined Transponders) Demo Completed



HEO Orbit

Eagle Satellite

- Proposed Launch 2009
- U/V transponder
- L/C/S Band coverage
- Analog and Digital packages aboard + groundstation equipment



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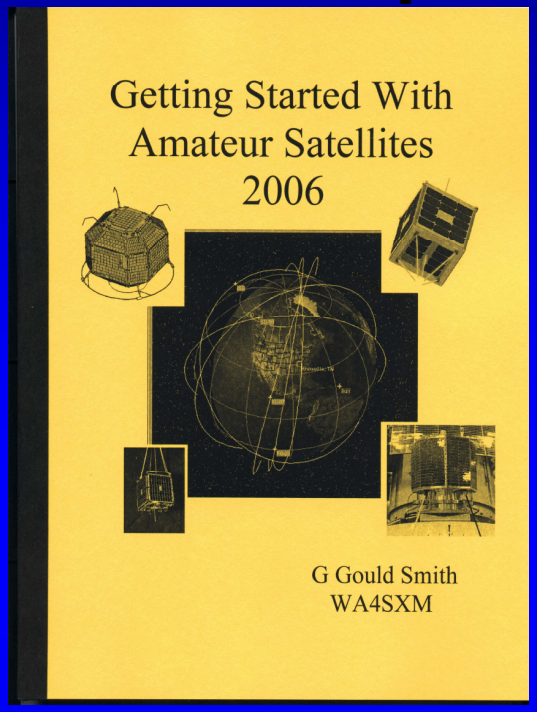
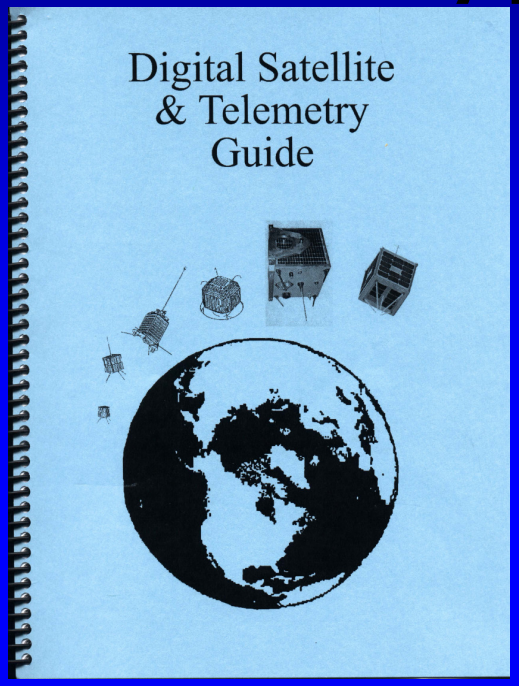
Use Satellite positioning tools online
Easy Satellite status & Freq charts

Check it out!

Books for Specific Satellite Types





- Getting Started With Amateur Satellites (2006)
  - Written to guide the Beginner into satellite operation
- Digital Satellite & Telemetry Guide (2005)

Periodicals

- The AMSAT Journal
(Published Bimonthly
distributed to membership)

- Magazines with Satellite Columns:
  - **QST**
  - **CQ VHF**
  - **CQ Magazine**
  - **73 Magazine**
  - **World Radio**

The AMSAT Journal

Volume 23, No. AO-40 – Special Phase 3D Launch Issue – November 2000

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- Visit the AMSAT Booth at Hamfests
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- Utilize the AMSAT Web Site: www.amsat.org
- Contact an AMSAT Area Coordinator
- Request a Club Satellite Presentation
- Consider Joining AMSAT/ Receive The AMSAT Journal

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e-mail: martha@amsat.org

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